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ABSTRACT

Changes in the composition of faculty with regard to age, tenure status, number of new members, average salary, turnover rate, and percentage of nontenured faculty receiving tenure are of concern to university policy makers. As a result of developments, such as changes in the mandatory retirement age and the limited growth of universities, assessing the nature and extent of changes in personnel characteristics, and determining the impacts of various personnel decisions upon these characteristics is important. A method is presented that provides insights into changing personnel characteristics and of the effectiveness of various changes in personnel policies. The method utilizes a Markov model of faculty flows and requires a minimum of two years of time series data concerning faculty age and tenure status. The impacts of six policies on the tenure status, salary, and age distribution of full-time faculty members at a large land grant university were analyzed. The policies are: (1) continuation of current hiring and retirement practices; (2) hiring only nontenured faculty; (3) hiring only assistant professors and instructors for the tenure track; (4) hiring only nontenured assistant professors and instructors for the tenure track; (5) mandatory retirement age extended to 70; and (6) mandatory retirement age at 65. The report demonstrates how these policies are modeled and discusses the various results. (JMD)

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THE USE OF A MARKOV MODEL IN ASSESSMENT OF ALTERNATIVE FACULTY PERSONNEL POLICIES

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HE 010 911

The Use of a Markov Model in Assessment of Alternative Faculty Personnel Policies

Introduction

As pressure increases for limiting growth of universities, because of both fewer prospective students and budgetary consideration, the resultant changing characteristics of the faculty become increasingly important. The future restriction to a stable number of total faculty may potentially create a change in the composition of the faculty with regard to age and tenure status. The influx of new faculty members may be reduced considerably as new appointments are limited to the number leaving the faculty. The percentage of faculty with tenure will change. The average salary may change, creating budgetary problems. The turnover rate among faculty members and the percentage of those non-tenured in the system receiving tenure may also be altered, affecting faculty morale. These and other changing faculty characteristics must be of concern to University policy makers.

Limiting faculty growth and turnover also potentially will alter the age structure. In addition, there is growing concern that changing the mandatory retirement age from 65 to 70 or eliminating mandatory retirement all together will also result in a change in faculty characteristics. A recent survey[1] indicates that retirement plans of large numbers of faculty are molded by their institution's retirement policies and that a change in official retirement age would lead many faculty members to revise their personal retirement plans. With the advent of a mandatory retirement age of 70, it is quite likely that a substantial number of faculty previously retiring at 65 will continue to work. The Ladd-Lipset Faculty Survey

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[1] The Ladd-Lipset Faculty "Survey," The Chronicle of Higher Education, November 7, 1977, p. 7.

indicated that raising the retirement age to 70 would lead to a significant number of faculty continuing past 65 years of age.

As a result of these developments, assessing the nature and extent of changes in personnel characteristics is most important, as is determining the impacts of various personnel decisions upon these characteristics. These issues are certainly not new to academic policy makers. However, many institutions do not have a reliable methodology which can be utilized to predict the effectiveness of various policy changes in modifying faculty characteristics. The following method provides useful insights into changing personnel characteristics and of the effectiveness of various changes in personnel policies. Moreover, it can be accomplished with basic personnel data despite limited time and monetary resources.

The method utilizes a Markov model of faculty flows as a basis for determining policy impacts. This is an accepted mathematical tool in the area of personnel management, well suited for use in academic institutions. Hopkins (1974) presents a concise discussion of its application in manpower planning.

The analysis requires a minimum of two years of time series data concerning faculty age and tenure status and can be designed to be as comprehensive as desired, data and resources permitting.

The analysis is valuable in a number of policy areas providing indications of future faculty characteristics in both the short run and steady state situations.

Methodology

Age and tenure characteristics of the full-time faculty at a large land grant institution were analyzed as impacted by alternate personnel strategies.

The specific policies examined here relate to both hiring and retirement policies and are as follows:

Policy 1: Continuation of current hiring and retirement practices.

Policy 2: Hiring only non-tenured faculty.

Policy 3: Hiring only assistant professors and instructors for the tenure track.

Policy 4: Hiring only non-tenured assistant professors and instructors for the tenure track.

Policy 5: Mandatory retirement age extended to 70.

Policy 6: Mandatory retirement age at 55.

The following report demonstrates how these policies are modeled and reports on the various results.

A Markov model is used to project the effect of alternate policies in faculty hiring and retirement policy on tenure status, salary, and age distribution. The Markov model projects past personnel movements into the future, assuming that the pattern of these movements extends into the future. It also allows for modeling various alternatives. For a more detailed description of the mathematical model refer to Hopkins (1974). In this study part-time and administrative faculty were excluded. Those moving into the administration are considered to be continuing while those moving from the administration are not included in the analysis. The faculty is split into two basic categories, tenure and non-tenure. Further breakdown in each of these categories is as follows:

Non-tenure

0-3 years credit toward tenure as of fall term

4-7 years credit toward tenure as of fall term

on leave

Tenure

less than 36 years of age as of September 1 of the fall term
36-40 years of age as of September 1 of the fall term
41-45 years of age as of September 1 of the fall term
46-50 years of age as of September 1 of the fall term
51-55 years of age as of September 1 of the fall term
56-60 years of age as of September 1 of the fall term
61-65 years of age as of September 1 of the fall term
over 65 years of age as of September 1 of the fall term
on leave

In order to project past trends of faculty movement, first a faculty flow model is developed indicating these trends. Each eligable faculty member is placed in one of the above mentioned categories in the initial year (Fall 1976) and collective movement from one category to another for the following year (Fall 1977) is recorded. This is used to develop a personnel flow matrix. This flow is then converted into proportions to create a transition matrix (see Table 1). The movement over this one year period is assumed to occur indefinately into the future. To complete the transition matrix it is also necessary to know the proportion from a given category in the initial year leaving the University system by the second year. Similarly it is also necessary to know the distribution of incoming faculty over the categories to determine where new faculty enter the system (input vector)

By adjusting the input vector or the proportion moving from different categories into retirement, one can simulate policy decisions and determine the likely impact on the age and tenure characteristics of the faculty. This in turn can be used to estimate percent of faculty tenured, average salary, and turnover rate.

The transition matrix was based on faculty movement for only one year, consequently modifications were necessary to correct unusual occurances in the original transition matrix. The first alteration was made in flow to and from non-tenured leave. Seven of the eight movements to the non-tenured leave category were from the 0-3 years service category, a likely occurrance. However, only two of the six returning from non-tenured leave returned to the 0-3 years service category. Over the long run this could not continue as individuals do not receive credit for service while on leave. Consequently, the probability for moving from non-tenured leave to 0-3 years service was increased to .347 and the probability for moving into the 4-7 years service category was decreased to .083. In addition, the anomaly of having a faculty member granted tenure while on leave for a second year was deleted.

Movement to and from the tenured leave category also required adjustment. During the observation period individuals were moving from certain age categories into the tenured leave category but there was no movement from the tenured leave category back to some age categories. This resulted in the impossible situation of individuals returning from leave at a younger age than when they left. Provisions were made for the proper flow of personnel back from tenured leave by altering the last row of the transition matrix. Finally, adjustments were made to movement from one age category to another. Over the long run the maximum percentage that can stay in one of the five year categories or go on leave is 80 percent. Due to the slightly uneven age distribution over the categories some categories had a greater percentage remaining during the one year observation period. The transition matrix was again adjusted to account for this.

Use of the Model

Short range projections are made with successive iterative runs of the data. The number of faculty who serve in each of the discrete categories is determined by multiplying the number serving in each category in the previous period by the specified proportions from the transition matrix and adding the incoming faculty to the results. The totals in each category then become the input for the next year. This is done year after year for as long as information is desired.

Steady state results can be obtained by continuing iterations of the short run projection until the proportion in a category no longer changes from one year to another. The same results can be obtained by utilizing complex matrix manipulations (Hopkins, 1974).

Alternate Strategies

All of the runs with the model assume that by 1983 the faculty will have stabilized at 1,485 members. Table 2 compares the alternate strategies in their effect upon the faculty characteristics: average salary, percent tenured, number of new faculty, and number of non-tenured faculty receiving tenure.

Present Conditions: Currently there are 1,369 full-time permanent faculty members at the University. Of the total, 55.7 percent are tenured with an average age of 46 years for tenured faculty. The average salary is $22,054.

Policy 1: This policy assumes that current hiring and retirement practices will continue without change into the future. If this is the case, by 1988 (within 10 years) the percentage of faculty with tenure will increase to 74.1 percent and upon reaching equilibrium will be 73.9 percent. The average

age will increase by 3.1 years to 49. With the increase in age and percent tenure, the average salary in 1977 dollars is projected to increase to $23, 919 by 1988 and reach equilibrium at $23,948, an 8.6 percent increase over the current average salary. The percentage of non-tenured faculty receiving tenure will be 10.6 percent in 1988 and will be 10.4 percent when the system reaches equilibrium, while the turnover rate is projected to be 8.1 percent (120 faculty) in 1988 and 8.6 percent (127 faculty per year) at equilibrium. Consequently, the number of new faculty will be only 120 in 1988 as compared to 212 in 1977.

Policy 2: In 1977, 17 faculty were hired with tenure. The second strategy assumes that hiring of faculty with tenure will be discontinued. The intent of this policy would be to potentially lower the percentage of the faculty with tenure while increasing the percentage of non-tenured faculty within the system receiving tenure. Although this would make it more difficult to attract well known faculty to the Institution, the prospects for younger, talented faculty members without tenure will be enhanced and they may be more likely to stay. Eliminating the hiring of faculty with tenure did lower the percent of the faculty tenured, but at equilibrium the percentage was still 71 percent. The increase in age of the tenured faculty is also slightly lower, increasing only to 47.9, an average of 2 years. The increase in average salary by 1988 was also reduced to 6.4 percent of the present average. The percentage of non-tenured faculty receiving tenure in 1988 and at equilibrium remained constant at 10.6 and 10.4 percent respectively, but the absolute number receiving tenure from this group increased. The percent turnover of the faculty increased slightly over Policy 1 to 8.8 percent after 10 years and 8.6 percent at equilibrium.

Policy 3: Another policy designed to lower the percent of tenured faculty is to limit hiring to only assistant professors and instructors in the tenure track. This strategy was modeled by determining movement from the 0-3 years credit category to a tenured position. The individuals instead move to the 4-7 years credit towards tenure (see Table 1, footnote 1). Consequently, new faculty remain in the non-tenure status longer. This policy had less effect upon the percentage of tenured faculty than alternative 2, as the percentage increased to 71.2 within ten years and reached 71.6 percent at equilibrium. There was also less impact upon the reduction of average salary and average age as the average salary increased by 7.6 percent over 1977 by equilibrium and the average age reached 48.9 years, only 0.1 year less than under policy 1. The percentage of non-tenured faculty receiving tenure in 1988 dropped to 9.3 percent. This policy had little impact on the rate of turnover at the University.

Policy 4: This alternative combines the two previous policies such that only non-tenured assistant professors and instructors will be hired for the tenure track. Tenure will not be a condition of hiring. This is an extremely limited hiring policy which may be deemed somewhat unrealistic but it is more efficient in reducing the change in faculty tenure status characteristics. If this policy is followed, by 1988 the percentage of tenured faculty will rise to 66.1 percent, reaching 67.1 percent at equilibrium, compared to 73.9 under policy 1. The impact of average salary increase will be significantly lower, increasing 4.9 percent in 1988 and 6.0 percent at equilibrium over current figures. The average age rises more slowly than under the other policies discussed but reaches 49.5 years of age at equilibrium, greater than the other hiring policies. The turnover rate increased to 9.3 percent at equilibrium, but the percentage

receiving tenure from the non-tenured faculty group in 1988 was only 9.3 percent, similar to or less than the other policies considered.

Two retirement policies were also run to observe their impact upon the system.

Policy 5: Under this alternative, faculty left the system by age 70. This is a likely policy to be instituted as Congress has recently raised the mandatory retirement age of the University faculty to 70 years of age, effective in 1982. Under this policy the percentage of the faculty with tenure increases to 74.8 by 1988, declining slightly to 74.5 percent at equilibrium. The average age of the faculty also increased slightly over the basic continuation of existing policy to 49.7 as opposed to 49 years of age. As expected, the turnover rate decreased very slighly to 8.4 percent at equilibrium. The percent of non-tenured faculty receiving tenure was not altered.

Policy 6: This policy is quite stringent, requiring mandatory retirement at age 65 with no exceptions. This policy is similar to the present with the exception that a few faculty members continue to work after reaching 65. Consequently, the results of this run are very similar to the basic run of a continuation of present policy; 73.4 percent were tenured with an average salary of $23,909, and an average age of 48.5 with an average turnover of 129 or 8.7 percent at equilibrium.

How long faculty remain

The length of time a typical faculty member will stay at the Institution can be calculated from the model used in this study. This length of time depends on the characteristics of the individual when joining the faculty.

The calculations involve combining information of the internal flow matrix with the entering and leaving vectors and summing columns of the resulting matrix after inversion (Hopkins, 1974). As shown in Table 3, those who join as non-tenured faculty will remain 10 to 16 years. Note that those who join in a tenure category typically will not move prior to eligibility for retirement. This is not to say that all who join the faculty with tenure will not leave, some will. It does show that the typical faculty member will not move again. As shown also in Table 3, inviting a faculty member to join with tenure means a long term financial commitment in excess of $600,000 for the younger faculty. Note that this is in constant 1977 dollars. This amount adjusted for inflation would be, of course, much higher.

Results of Analysis

Figure 1 shows the effect of three likely policy strategies upon the percentage of tenured faculty. Figure 2 indicates the effect of hiring policies on the average salary at the University.

1. If current hiring and retirement practices are continued into the future, the percentage of tenured faculty will rise from 55.7 percent to 73.9 percent if the ultimate level of faculty does not exceed 1,485.

2. Three possible hiring policy alternatives were considered as a means of altering this percentage: 1) eliminating hiring with tenure; 2) hiring only assistant professors and instructors with tenure track positions; 3) combining the two. Although the third policy is very stringent, is is the most effective in lowering the percent of tenured faculty and average salary.

3. Placing an upper limit on total faculty members will cause a

substantial increase in percent of faculty tenured and on the average salary regardless of the policy alternatives considered in this report.

4. Impact on the University budget for faculty salaries will be substantial. If current practices continue, the increase in average salary due first to change [illegible] and tenure status will increase the budget in 1977 dollars by [illegible]. If policy 4 is followed, the increase will be $1,799,820, over [illegible] million dollars less.

5. The average age of the faculty will rise above the present level under all of the alternatives considered but in no case does it rise above 50 years of age.

6. Increasing the mandatory retirement age to 70 will slightly aggravate the percent of faculty with tenures and average salary situation.

7. The increase in mandatory retirement age to 70 will also have the expected impact of lowering the number of new faculty entering the system but not substantially less than the present personnel policy.

8. The percentage turnover of full-time faculty is not expected to vary more than 1 percent at equilibrium.

9. The number of new faculty members entering the system drops rapidly from the 1977 level of 212. Policy 4 will allow the greatest number of new faculty to enter the system (see Table 2).

10. The average time an individual faculty member spends at Virginia Tech is much higher if one enters as a tenured faculty member. This results in a greater total salary commitment per individual and per position (see Table 3).

Conclusions

The description on the preceeding pages is an example of the type of

policy analysis that may be undertaken using a Markov model of faculty flow. Analysis is not limited to those policies mentioned here, as the model itself is quite flexible can be expanded to include other classes of faculty such as extension and part-time faculty. If it is felt that two years of data is insufficient, additional years may be incorporated when developing the faculty flow model.

The procedure is a very useful policy analysis tool. Although it is not a perfect predictive device, it allows quick assessment of the impact of various personnel policies which are modeled quite easily by manipulating the proportions in the Markov faculty flow model.

Figure 1

Percent Faculty Tenured for Three Policy Alternatives

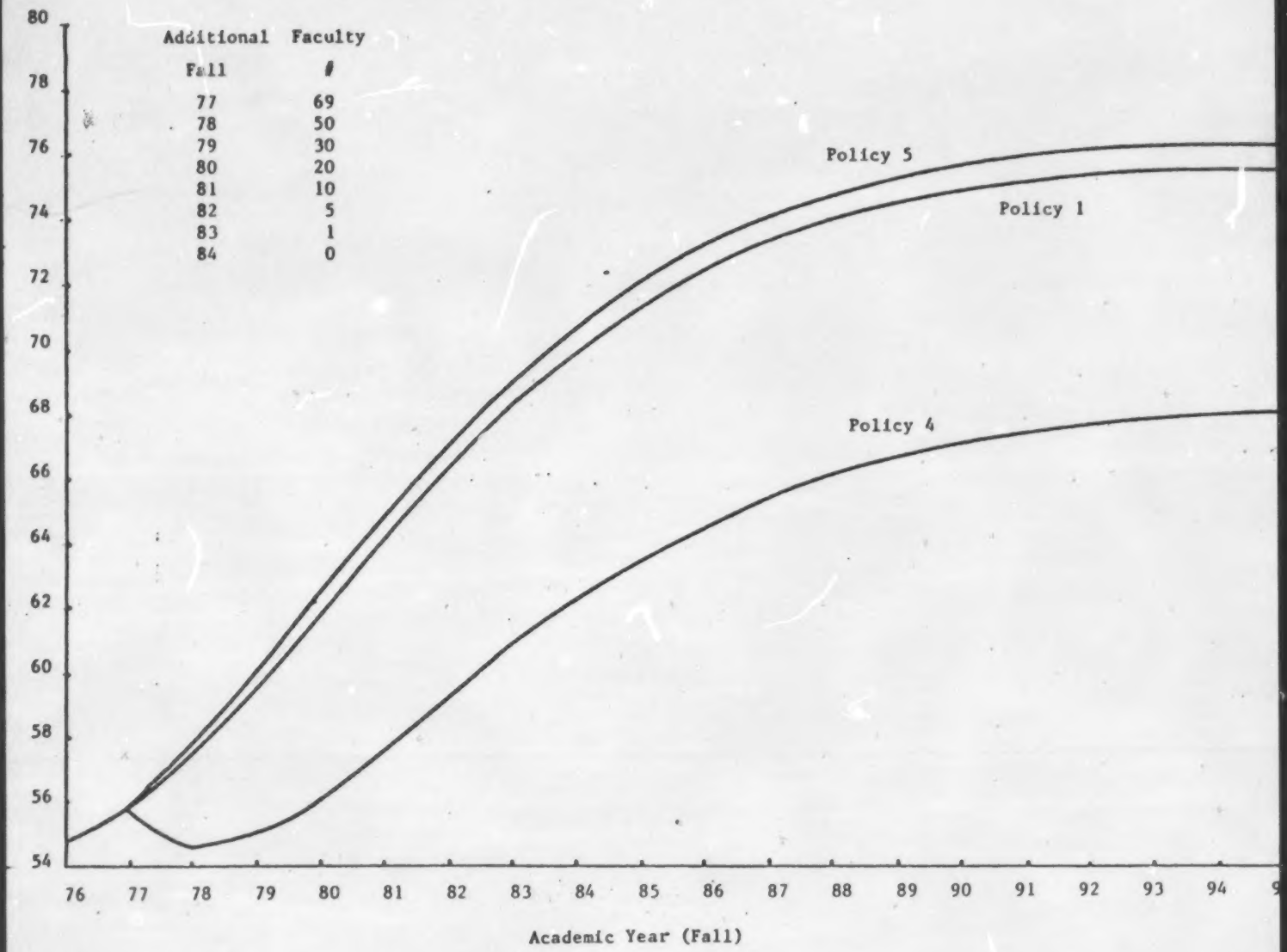

Figure 2

Average Tenured Faculty Salary for Alternative Hiring Policies

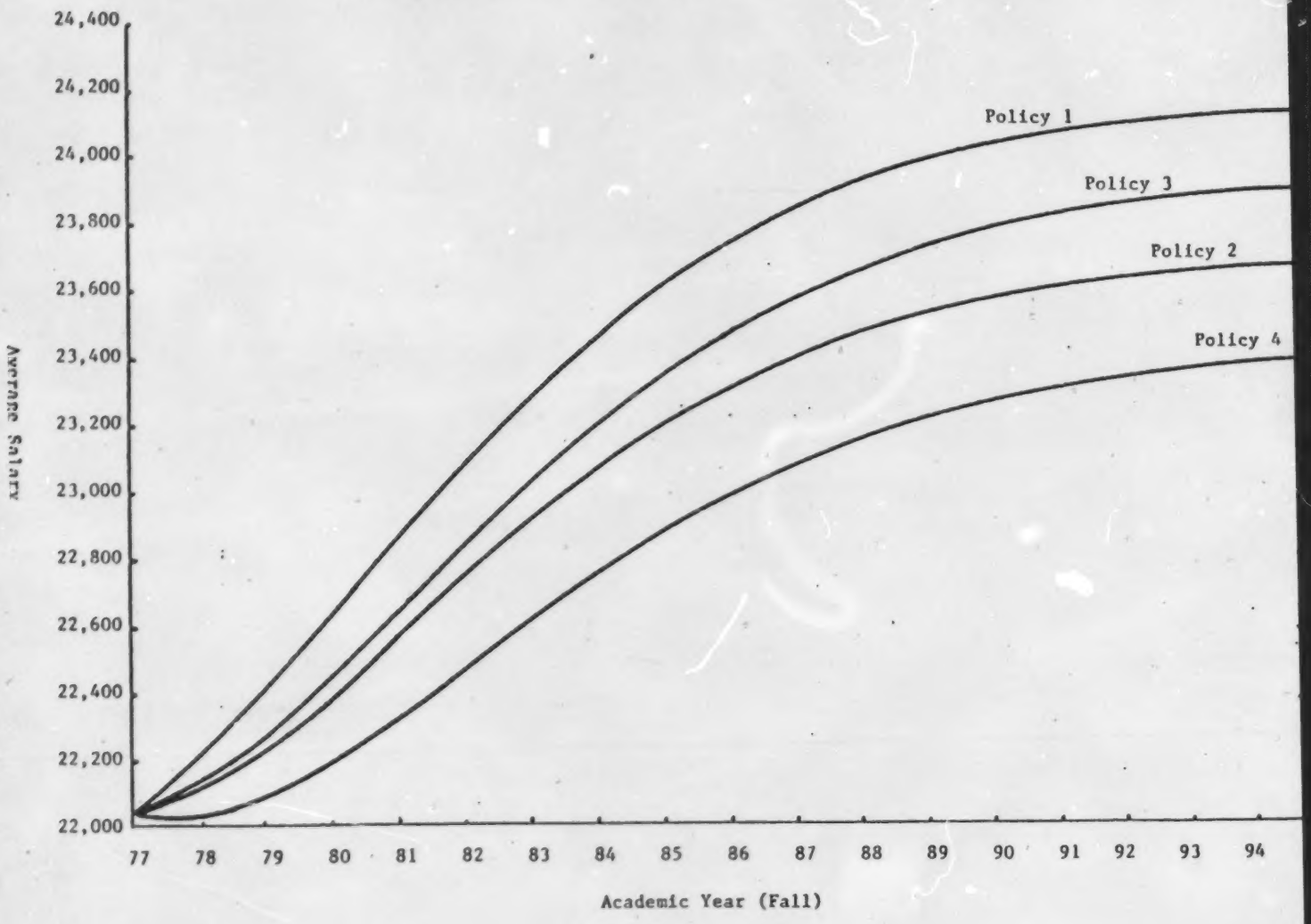

Table 1

Adjusted Transition Matrix

	Non-tenured			Tenured (age)							
Category	0-3yrs	4-7yrs	Non-tenured leave	35+under	36-40	41-45	46-50	51-55	56-60	61-65	over65	Leave
Non-tenured												
0-3years[1]	.6149	.1255	.0149	.0170	.0170	.0064	.0043	.0021	.0021[1]	0	0	0
4-7years	-	.4666	.0095	.1809	.0957	.0286	.0286	0	0	0	0	.0190
non-tenured leave	.347	.083		0	0	0	0	0	0	0	0	0
Tenured (age)												
35+under	-	-	-	.6506	.3012	-	-	-	-	-	-	.0241
36-40	-	-	-	-	.7579	.1594	-	-	-	-	-	.0526
41-45	-	-	-	-	-	.7848	.1773	-	-	-	-	.0190
46-50	-	-	-	-	-	-	.7768	.1964	-	-	-	.0089
51-55	-	-	-	-	-	-	-	.7835	.1855	-	-	.0206
56-60	-	-	-	-	-	-	-	-	.7774	.1803	-	.0282
61-65	-	-	-	-	-	-	-	-	-	.6586	.1220[2&3]	0
over 65	-	-	-	-	-	-	-	-	-	-	.6000	0
tenured leave	-	-	-	.0842	.3158	.2000	.0737	.0947	.1053	.0211	0	.0526
Entering	.9198	0	0	.0094	.0189	.0236	.0294	.0142	.0047	0	0	0

1 Under policies 3 and 4 flow was not allowed from the 0-3 years credit toward tenure category to tenure categories as assistant professors and instructors can not receive tenure until gaining more than three years credit toward tenure. Thus, the row was changed (.6149, .1745, .0149,0,0,0, 0,0,0,0,0,0, .1957).

2 Under policy 5, six of seven of those retiring from the 61-65 age category were allowed to continue into the over 65 category, the proportion moving from 61-65 to over 65 changed from .1220 to .2682.

3 Under policy 6, all those continuing past 65 years of age are forced to retire. The proportion moving from 61-65 to over 65 changes from .1220 to 0.

Table 2

Impact of Policy Changes Upon Selected Faculty Characteristics
By 1988

	Average Faculty Salary (1977 $'s) as Percent of 1977 Average Salary	Percent of Faculty Tenured	Number of New Faculty	Non-tenured Faculty Receiving Tenure	
				%	#
Policy 1	108.5	74.1	120	10.6	41
Policy 2	106.4	69.6	130	10.6	48
Policy 3	107.3	71.2	125	9.3	40
Policy 4	104.9	66.1	136	9.3	47
Policy 5	108.7	74.8	116	10.7	40
Policy 6	108.2	73.4	123	10.6	42

Policy 1: Continuation of current hiring and retirement policy

Policy 2: Discontinue hiring new faculty with tenure

Policy 3: Hiring limited to only assistant professors and instructors

Policy 4: Hiring limited to only assistant professors and instructors, non-tenured

Policy 5: Mandatory retirement at 70

Policy 6: Mandatory retirement at 65

Table 3

Steady State Characteristics

Category	Average Age[1]	# of Observations	Average Salary	Years Spent at VPI & SU[2]	Effective Salary Com[3]
Non-tenured					
0-3 years	-	486	$16,724	10.97	$257,979
4-7 years	-	112	18,223	16.47	417,807
Leave	-	8	15,188	-	
Tenured					
35 & under	33	86	22,486	23.66	615,532
36-40	38	148	25,141	22.44	595,134
41-45	43	164	26,320	20.89	563,354
46-50	48	117	28,637	17.25	469,582
51-55	53	106	26,984	13.30	354,150
56-60	58	74	26,141	8.52	225,266
61-65	63	37	27,287	3.82	102,938
over 65	67	9	25,790	2.5	64,475
leave	-	21	24,803		

1. Data only for tenured faculty. The midpoint of the category was used as average. For categories 35 and under and over 65 the figures were checked for accuracy.

2. Time spent in tenure track if entering in that category under current hiring and retirement policy. The policy alternatives considered had little effect.

3. If entering in that category the average salary commitment per individual for current hiring and retirement policy.

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